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## 2022 Serventy Memorial Lecture
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### Introduction

The Serventy Memorial Lecture: supporting students while recognising the important contributions of the Serventy Family.

The Serventy family made outstanding contributions to the Western Australian Naturalists' Club, to Australian natural history and to the awareness of environmental issues during the twentieth century. There were five members of the Serventy family who contributed: Dr Dominic (Dom) Serventy, Miss Lucy Serventy, Dr Vincent (Vince) Serventy, Mrs Carol Serventy and Mr John Serventy.

Dom Serventy was a founding member of the Club in 1924 when he was just 20 years old. He was the first Secretary-Treasurer, served as President and was editor for 33 years. Dom became an eminent Australian ornithologist, working at CSIRO Wildlife Division and publishing a number of landmark books and journal articles during his career.

Lucy Serventy, Dom's sister, contributed a lifetime of voluntary service to the WA Naturalists' Club, was Club Treasurer for over 30 years, organised junior and senior excursions and many other activities.

Lucy and Dom's brother Vince was a CSIRO researcher and teacher, writer, lecturer and film-maker, presided over many Club activities and spent his life working in environmental education both professionally and in a voluntary capacity throughout Australia. Carol Serventy, Vince's wife, supported his various activities, and John Serventy was Treasurer of the Club in the late 1950s and early 1960s.

The Serventy family's contributions to natural history have been recognised by various organisations. The DL Serventy Medal is awarded each year by BirdLife Australia to recognise Australia's leading ornithologists, in Dom's honour. The Australian Wildlife Society also honour the Serventy family by recognising an environmental volunteer each year with the Serventy Conservation Award.

The WA Naturalists' Club established the Serventy Memorial Fund [now called the WA Naturalists' Gift Fund] in honour of the Serventy family to encourage young naturalists, help young people take part in excursions and individual projects and, since 2002, has funded natural history prizes for students at WA's four public universities. Winning students receive a $500 prize, as well as a year's

membership to the Club, and the opportunity to present a focus talk at a meeting or write an article for WA Naturalist.

All proceeds from the annual Serventy Memorial Lecture are used to support students of natural history, in recognition of the enormous contributions made by the Serventy family to the WA Naturalists' Club and to conservation and natural history in Australia.

Mandy Bamford

# Biodiversity matters

# Western Australia - people and nature influencing global decisions

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*I would like to acknowledge the traditional custodians on whose lands I have worked and those who have taught me ways to move forward.*

**Abstract**

Western Australia (WA) is known locally and internationally for its high levels of biodiversity, across the 26 bioregions, close to 1/3 of Australia's lands. Not only does WA have significant biodiversity, but significantly important relationships of traditional custodians living in and maintaining these landscapes across 60,000+ years. I will share with you how the knowledge I have gained, and experiences over 30 years working with communities across many of WA's natural habitats, are influencing international responses to solutions to prevent biodiversity loss and advance relationships of people with nature. We work to bring change locally and globally to enable the planet and its people to respond to changing climates while providing healthy biodiverse landscapes for the future.

My international work has been influenced by my experiences with WA's biodiversity and communities, has influenced the International Union for the Conservation of Nature over 10 years, and as an elected member of the Intergovernmental Platform on Biodiversity and Ecosystem Services, a sister organisation to

the Intergovernmental Platform on Climate Change. I have been a member of Intergovernmental Platform on Biodiversity and Ecosystem Services Multidisciplinary Expert Panel for four years, which provides technical advice to member governments of the United Nations' Intergovernmental Platform on Biodiversity and Ecosystem Services, a sister organisation to the Intergovernmental Platform on Climate Change. We share solutions, endorsed by member governments, which are being taken up across the globe to advance people's approaches on ways forward to preserve the landscapes to which we all feel connected.

## Introduction

It is critical, as we work to maintain a healthy planet, that we expand the understanding, knowledge and experiences of biodiversity to as wide an audience as possible. As people from all walks of life come to understand the importance of the natural environment, and interact with it, we will place the future of the planet in a far more positive place.

**Figure 1.** Judy Fisher, 2022 Serventy Memorial Lecturer.

With the aim of expanding people's worldviews about biodiversity and the natural environment, the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) has been developing robust scientific knowledge to advance this cause over the past decade (https://ipbes.net/).

In addition, IPBES has played a key role in bringing together the key international organisations working on biodiversity-related matters to improve future planetary health. These include:

- IPCC Intergovernmental Platform on Climate Change
- CBD Convention on Biological Diversity
- Ramsar Wetlands
- UNCCCD Convention to Combat Desertification
- CITES International Trade in Wild Species
- UNEP United Nations Environment Programme
- IUCN International Union for the Conservation of Nature
- International Indigenous People's Forum on Climate Change
- International Indigenous Forum on Biodiversity

For the past three years IPBES has been nominated for the Nobel Peace Prize.

In July 2020 I was privileged to attend the 9th IPBES Plenary Meeting of the 139 member states in Bonn, Germany, where two new assessments were approved by governments, bringing this to 10 assessments over the decade in which IPBES has been in operation. IPBES is the sister organisation to the well-known IPCC, which has provided the evidence needed to persuade the world that we need to take dramatic action on addressing the negative impacts of human-made or anthropogenic climate change.

The two new IPBES assessments released in July 2022 were the "Diverse values and valuation on nature" (IPBES 2022a) and the "Sustainable use of wild species" (IPBES 2022b). These assessments were the result of four years of work by 85 leading scientists and experts from all regions of the world. A key finding from the values assessment (IPBES 2022a) was that there is a dominant global focus on short-term profits and economic growth, which often excludes the multiple values of nature in decision-making. Economic and political decisions have predominantly prioritised certain values of nature, particularly market-based values which do not adequately reflect how changes in nature affect people's quality of life. This assessment (IPBES 2022a) also builds directly on the 2019 IPBES global assessment (Díaz *et al.* 2019) which identified the role of economic growth as a key driver of nature loss (https://ipbes.net/global-assessment). IPBES (2022a) also highlighted how different worldviews and knowledge systems influence the ways people interact with and value nature. The sustainable use of wild species (IPBES 2022b) report highlighted that recognising and respecting the worldviews, values and traditional knowledge of indigenous peoples and local communities and the role of women in the stewardship of nature can advance the inclusion of the diversity of values and worldviews in decisions made about the natural environment. It provides the evidence that shifting decision-making towards the multiple values of nature is an important aspect of the system-wide transformative change needed to address the current global biodiversity crisis. Biodiversity is being lost and nature's contributions to people's well-being are being degraded faster now than at any time in human history. This is largely due to the current approach to political and economic decisions which does not sufficiently account for the diversity of nature's values. The key findings outline the need to shift all decisions towards better values-centred outcomes for people and the rest of nature.

The findings from this assessment can be very helpful to advance the work of the members of the WA Naturalist Club who have been working tirelessly to maintain the natural environment (https://ipbes.net/the-values-assessment) by ensuring discussions and so results by decision makers begin to include diverse worldviews and the multiple values of nature, not just those included in legislative and regulatory agreements.

In addition to the approval of two new assessments I was heavily involved at the Bonn Meeting in July 2022 of the member states' discussions which resulted in the approval of the IPBES scoping

report for a new assessment on "A methodological assessment of the impact and dependence of business on biodiversity and nature's contributions to people" (IPBES 2022c). The findings from the values assessment (IPBES 2022a) identified some of the key problems associated with biodiversity loss being those associated with current approaches to political and economic decisions. The business and biodiversity assessment which will begin soon, will focus on businesses understandings of not only the impact their decisions are having on biodiversity, but will also strongly focus on bringing an understanding to businesses on how dependent for success they are on the natural environment. This is a topic which WA Naturalist Club members could bring into any discussions they may be having with developers.

The workshop report co-sponsored by IPBES and IPCC (IPBES 2021), released in June 2021, has provided scientific evidence to demonstrate that biodiversity loss and climate change are inseparable threats to humanity which must be addressed together. In essence, if we tackle threats to climate change alone, we may in fact be contributing to biodiversity loss which is just as great a threat to the future of the planet as climate change (https://ipbes.net/events/ipbes-ipcc-co-sponsored-workshop-report-biodiversity-and-climate-change).

Since the release of that report, many actions around the world are now considering these two threats in partnership, including activities of the IPCC which is now considering biodiversity loss in all its ongoing climate-based work. This evidence can provide great impetus to the members of the WA Naturalists Club not only in their discussions about protecting biodiversity from the impacts of climate change, but also in considering climate impacts on the natural and the latest scientific evidence that biodiversity loss can no longer be tolerated if we wish to maintain the integrity of the planet.

A further IPBES workshop report of particular relevance to WA Naturalist Club members is the "Biodiversity and pandemics report" (IPBES 2020; https://ipbes.net/pandemics) which brings together the most scientifically robust examination of the evidence and knowledge of the links between land-use change and the synergistic effects between climate change and biodiversity loss which leads to diseases and pandemics such as COVID-19. Pandemic risk can be significantly lowered by reducing human activities that drive the loss of biodiversity, by greater conservation of protected areas and through measures that reduce unsustainable exploitation of high biodiversity regions. This will reduce wildlife-livestock-human contact and help prevent the generation of new diseases. Our current focus is on containing and controlling diseases once they emerge; however, examination of the evidence indicated that we can escape the era of pandemics with a greater focus on prevention that considers carefully the wider impacts of land use change and biodiversity loss in decision making.

These outstanding reports provide an assessment of the evidence to prove that "Biodiversity Matters" in a number of integrated ways. Biodiversity has its own intrinsic value distinct from the value it provides to human life. For all species, biodiversity provides food, water, shelter and the functioning of the whole Earth system. For people,

biodiversity is an integral part of our spiritual, cultural, psychological and artistic wellbeing. These wider interpretations of biodiversity are being implemented globally and have the potential to further influence decision making here in WA if brought to the fore of discussions to influence decision making.

**International contributions influenced by experiences with Western Australia's biodiversity and communities**

I have contributed to the work of IPBES for the past eight years both as an author and for the past four years as a member of the IPBES Multidisciplinary Expert Panel (MEP) (https://ipbes.net/multidisciplinary-expert-panel). The MEP is an elected body with five experts from each United Nation region. I was elected by and represent the Western Europe and other Grouping (WEOG) countries. The role of the MEP is to oversee the technical aspects of all of the IPBES work programmes. Prior to my role on the MEP I have been a co-ordinating lead author of the IPBES Land Degradation and Restoration Assessment (Fisher *et al.* 2018; Scholes *et al.* 2018; https://ipbes.net/assessment-reports/ldr) and lead author in the Asia Pacific Assessment of Biodiversity (Davies *et al.* 2018; https://ipbes.net/assessment-reports/asia-pacific).

IPBES recognizes that indigenous peoples and local communities possess detailed knowledge on biodiversity and environmental change and are important contributors to the governance of biodiversity from local to global levels. Indigenous and local knowledge is a cross-cutting issue for all IPBES's activities and is well-recognised as a leader in incorporating indigenous knowledge into assessments in a manner supported by indigenous peoples and incorporating Free Prior and Informed Consent. During my authorship of the land degradation and restoration assessment (Fisher *et al.* 2018) I was responsible for seeking out indigenous literature to be incorporated across all chapters of that assessment. During my time on the IPBES MEP I have been a member of the IPBES Indigenous and Local Knowledge Task Force (https://ipbes.net/indigenous-local-knowledge) which oversees and takes part in the implementation to "enhance the recognition of and work with indigenous and local knowledge systems" and acts to build on lessons learned in the implementation of the approach to recognising and working with indigenous and local knowledge in IPBES.

In contributing significantly to the outputs of IPBES through these differing roles, I have incorporated the knowledge I have gained through working on projects across WA for the past 30 years including a PhD in Perth's Bold Park titled: "Fundamental changes to ecosystem properties and processes linked to plant invasion and fire frequency in a biodiverse woodland" (Fisher 2007). This PhD resulted from significant field work aimed to understand the interactions between fire frequency, soil nutrients, invasive species, native vegetation and invertebrates in order to understand the ecosystem and advance innovative restoration actions (Fisher *et al.* 2006; Fisher *et al.* 2009a; Fisher *et al.* 2009b).

Running in parallel with the PhD I became involved with my children's local school, City Beach Primary School. In the 1990s, students worked

to "bring back the bush" in their school grounds, in partnership with Robert Powell (Fisher & Campbell 1996). This became a critically important education programme and expanded over a decade, linking bush garden education across all year levels, incorporating all staff and parents, with an after-school activity programme for interested students called the Bush Guardians. This was later mimicked by the then Department of Conservation and Land Management to develop the Bush Ranger Programme which has remained an important educational programme for the Department. The student members of the Bush Guardians won numerous awards including the Landcare Award and Greening Australia Award. Throughout this period, the school provided advice on linking such programmes into the school curriculum to well over 20 schools. In addition, the programme played a key role in the development of Water Corporation's Water Wise Schools programme. This was based on the work of the students in developing a nursery which propagated local native species utilising seed form the bush garden and collected on excursions into Bold Park. Community days were held in which plants propagated by the students were sold to the local community while also educating them on the benefits of water wise local native plants to reduce water usage. This programme was also delivered by teachers within the school curriculum and City Beach rapidly reduced its water usage which was evidenced to be a direct result of the schools' programme.

With an advanced interest in invasive species gained from this PhD and other activities related to invasive species during this period including as chair of the ministerial-appointed State Weeds Committee (Western Australian Weeds Committee 2005), it became increasingly obvious to me that to effectively tackle the topic of invasive species it was critically important to consider the topic from an ecosystem perspective, whereas much work had been focused on individual species of significance. Seeing an increasing need to think more holistically on the topic, I was asked in 2013 by the IUCN Commission on Ecosystem Management to begin a new thematic group titled Ecosystems and Invasive Species. Beginning with a membership of one, myself, I quickly expanded the membership to members from 50 countries. During the eight years of its existence the group changed the thinking globally, and attempts to integrate a more holistic approach to successfully tackling the menacing problem of the impacts of invasive species on biodiversity. This thinking has also influenced the ongoing IPBES invasive species assessment which will be presented to governments in 2022.

Key to provide the evidence for this change in thinking has been the development of an innovative integrated approach to the baseline measurement of invasive species to understand the ecological and economic effectiveness of restoration over time, with the base measure being invasive species cover. This approach was first developed with the Stirling Natural Environment Coastcare (SNEC) along the 6.5 km of the City of Stirling coastline. The methodology was developed and enhanced over several years, including having time to conduct a re-measurement once on-ground activities had been conducted. The incorporation of ecosystem changes

and also the economic effectiveness of the management interventions quickly led the land manager of the City of Stirling to understand how effective the community group and their financial investments had been in improving the biodiversity along the entire coastline, and in particular in significantly reducing the impact of invasive species (Fisher 2015). This understanding led the City of Stirling to utilise the same methodology across the 170 ha of Trigg Bushland Reserve. The methodology was further enhanced during this mapping to take into consideration the many different plant communities across the reserve (Fisher 2018). In 2019 the success of the approach was acknowledged with SNEC winning the United Nations Australia WA Environment Award.

As word started to travel about the methodology, the City of Mandurah began to explore the benefits of implementing such baseline measures across their biodiverse reserves. As time has moved on the City of Mandurah have been impressed with the utilisation of the approach and particularly with its ability to measure and understand the economic effectiveness of their on-ground works. This work is progressing and to date 30 reserves have been mapped using the invasive species baseline cover methodology. All field data collected within each invasive species cover polygon including native species, weed species, plant community type based on dominant overstorey and shrub species, presence of invasive and native animal species, and vegetation condition, is incorporated directly into a Geographic Information System (GIS) providing the City of Mandurah with an extensive biodiversity database for all reserves. This dataset then forms the basis from which a management plan is developed with activities conducted in the field incorporated into the same GIS system (Fisher 2020).

In addition, the approach has also been extended to the farming system at Wheelhamby Farm, a mixed carbon farming property in a low rainfall area, near Perenjori. In addition to agricultural land, Wheelhamby farm has 100 ha of remnant vegetation scattered throughout the farm landscape. By further advancing the previously mentioned methodology to suit the needs of a farming operation we have provided the farm with an important biodiversity dataset which prove the benefits of biodiversity as a natural asset which will enhance cropping and animal systems, while restoring and protecting biodiversity. The biodiversity database will also be a valuable asset as the emerging biodiversity credit systems evolve.

The work from these field-based projects will be published as an IUCN Commission on Ecosystem Management Best Practice Case Study using baseline mapping to measure the ecological and economic success of restoration, particularly relevant as we are now in the UN Decade of Restoration (2021–2030).

Not long after completing my PhD, I utilised the knowledge gained to work with the traditional owners and rangers of the Kimberley's Dampier Peninsula to work with them to develop science-based programs which they could implement to protect and conserve the culturally significant monsoon vine thickets. Through this program we developed vegetation structure protocols which the rangers implemented to understand the vegetation structure deep within the

monsoon vine thickets, at the edges where most disturbance occurs, and in the neighbouring Pindan woodlands (Fisher & Beames 2012). We also developed protocols for understanding ant community structure in similar locations, providing us with important data to understand the monsoon vine thickets (Fisher *et al.* 2014). In addition, we conducted an analysis using remote sensing data, over a long period, to identify when fires occurred in the vicinity of the 72 monsoon vine thickets across the Damper Peninsula. We were able to establish the season of burn, early dry season or late dry season, and the frequency of fire for all monsoon vine thickets. We utilised this data to analysis the change in vegetation structure for each monsoon vine thicket over time in relation to the frequency and season of fire. This data provided highly significant outcomes, particularly when combined with the vegetation and ant community field data collected by the rangers for six monsoon vine thickets. This was the first data to identify the impacts on the monsoon vine thickets of fire and in particular by late dry season fires and was significant in changing fire operations to focus on early dry season fires to maintain the integrity of the monsoon vine thickets (Beames *et al.* 2010). Not only was the data significant for management actions but also enabled the monsoon vine thickets of the Dampier Peninsula to be listed as Endangered under the Environment Protection and Biodiversity Conservation Act (https://www.environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=105).

Running in parallel with this project were significant science programs conducted with the South East Regional Centre for Urban Landcare (SERCUL) and in particular working closely with SERCUL CEO Julie Robert to establish baseline measures of biodiversity prior to urban waterway renewal projects. We aimed to be able to measure the changes in biodiversity, particularly in response to the removal of invasive species, over time (Fisher 2011).

As part of this renewal programme the first living stream was developed along Bannister Creek in response to the Bannister Creek Management Plan, which I developed (Fisher 1998). The living stream was developed in an urbanised section of the creek which had been converted to a drain many years previously. The results were outstanding, working with the City of Canning engineers and the Water and Rivers Commission, the community and many others to develop what has now become a critically important example of the benefits of moving away from urban drains, replacing them with meandering and functional creek systems. Their effectiveness has benefited not only the removal of nutrients from within the river system due to the presence of the native vegetation, but also returned missing biodiversity to the aquatic and vegetation ecosystems which has enabled the creek to function, providing heightened ecosystem benefits. Property values in the locality of the living stream also increased in greater proportion to other locations in the vicinity of Bannister Creek, indicating the value that people placed on these converted drains. Living streams are now common throughout urban areas.

Further work has been conducted with traditional owners in the Kimberley since the Monsoon Vine

Thicket Project. This includes working with traditional owners along the Fitzroy River and most recently with the Wunambal Gaambera Traditional Owners (Fisher 2021). IPBES was very keen to understand more of the traditional owners from the Kimberley so much so that they produced a Nature Insights programme with Traditional Owners which was distributed globally to a wide global audience (https://open.spotify.com/episode/0NL9UaQd1ucHZ7FlAfjV1e).

**IPBES and Western Australia**

A number of key projects I have been involved with across WA have laid the foundations for the knowledge contributed through my eight years of involvement with IPBES. It is the knowledge gained and experiences established through the examples provided in this paper, along with numerous other community and academic connections, which have enabled me to bring an understanding of WA's unique biodiversity, and the unique knowledge of WA's traditional custodians into the work of IPBES. As the work of IPBES becomes more and more globally recognised it is to be hoped that the WA community indulge themselves with understanding the findings from these IPBES assessments to advance their work and desires for the future of WA's unique biodiversity, in the same way that the findings of IPCC Reports have been utilised.

The key focus of IPBES now and others working to advance the importance of biodiversity globally will be the invasive species assessment to be released in 2022. In addition, two new assessments have recently begun. One is an assessment on the nexus between biodiversity and water, food, health and climate. This is critical work in which we are working to bring an understanding to the world of the importance of working on the interactions of biodiversity across all these sectors and not in isolation or siloing each other. Another critical assessment under way is that on transformational change through which we will bring to the world an understanding on how we can make the most critical changes required locally, regionally and globally to prevent biodiversity loss, moving away from the business-as-usual scenario towards the transformational approaches needed to sustain biodiversity across the planet.

As an outcome from the IPBES global assessment was the development of the UK Government's Review of Economics called the Das Gupta Review on the Economics of Biodiversity (Das Gupta 2021). Critical to the maintenance of biodiversity and prevention of biodiversity loss will be changes to the economic system as highlighted by this review through the following quotes:

> "Transformative Change is possible - we and our descendants deserve nothing less"
>
> "Biodiversity is essential for human existence and good quality of life.

The wider benefits of biodiversity are not fully replaceable, and often irreplaceable"

The Das Gupta Review provides the evidence and alternatives as to why we need to move away from Gross Domestic Product as the base of our economic systems and replace it with an economic focus which measures the assets provided by biodiversity and the natural environment.

In the words of Sir David Attenborough who is a spokesperson for the Das Gupta Review on Biodiversity:

> "The value of biodiversity is not the same as its price."

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## Focus on Friends

# The Toodyay Friends of the River

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### Background

At 200 km in length (excluding the Swan River) the Avon River is the longest river in southern Western Australia (WA). Its catchment drains some 120,000 km$^2$, roughly the size of Tasmania. This watercourse is sometimes referred to it as a "back to front river": its catchment is predominately flat, whereas the downstream end cuts its way through the great, granite barrier of the Darling Range. Confined by this ravine, the flow can become a violent torrent with churning rapids that are a magnet for white water enthusiasts. Beyond the hills the Avon becomes the Swan River and flows calmly across the coastal plain (Pen 1999).

The sub-catchments of the Avon system are mostly formed by chains of salt lakes and clay pans and include the Mortlock and Lockhart Rivers and the Yilgarn River extending eastwards to the goldfields. During significant rain events these tributaries can join and send flood waters down the Avon River (Walker 1986; Read & Sands 2008). This river has a history of flooding, with the highest recorded level occurring in 1872 and is regarded as a one in a hundred year event. The effect of regular flooding caused early Toodyay settlements to relocate to higher ground (Erikson 1974).

The Avon catchment is dominated by broad scale agricultural production, namely cropping and grazing. Most of this land was cleared during the years following the Second World War. The effect of removing the extensive woodlands caused water tables to rise and bring salt to the surface rendering vast areas unproductive. In addition, increasing erosion, weed invasion and dramatic declines in biodiversity have resulted (Beresford *et al.* 2001; Jones *et al.* 2009).

From the early days of European settlement in the Toodyay district, livestock grazed along the banks of the river and its tributaries (Cromb 2016). As recently as the 1970s industrial waste and sewerage was pumped into the river. Locals considered the river was a convenient place to discard rubbish and abandon cars. Farmers would dump unwanted machinery, chemical drums and fencing materials and councils located their landfill sites on the riverbanks (Chitty 2004).

But these environmentally destructive activities would escalate with the commencement of the so-called River Training Scheme (RTS) of the 1950s and 1960s. This was to be a tragic example of the consequences of poor environmental decision-making based on naïve understanding of how rivers function. The state government sanctioned this ill-conceived plan to reduce the effects of flooding. Almost the entire length of the river was bulldozed with fringing vegetation removed and the river bed ripped up over a 20 year period; however, no appreciable flood mitigation

was achieved. Instead, it caused the mobilisation of sediments that filled in chains of previously deep, permanent pools (Bremner 2015).

Erosion, loss of habitat, salinisation and invasion of weeds were other consequences. Chemical and fertiliser run-off has reduced the water quality of the Avon to an "unusable" condition. Many had warned of the environmental and social costs of this programme, especially the late Jim Masters OAM (1917–2001) who tirelessly campaigned to protect the river from the RTS.

Adding to the heartbreak, no heed at all was paid to the significance of the river to the Ballardong people of the wider Noongar nation, through whose land the river flowed. They call it Gulgulgar Bilya and it is sacred to them. The Ballardong people made use of the river for hunting, fishing and gathering resources and as a meeting place of tribes (Wheatbelt Natural Resource Management Inc. undated).

**Beginnings of the Toodyay Friends of the River (TFOR)**

In the 1980s, however, amid rising awareness and concern for the natural environment, there was a strong desire to restore the ecological and cultural values of the Avon River. Communities along the Avon River began to ask what could be done to stop the decline, and from this desire the seeds of the TFOR were planted.

The Avon River Management Authority (ARMA) was constituted under the 'Waterways Conservation Act 1976' with responsibility and authority to manage the river. It was required to work towards developing a management plan and had varying roles and powers, including a pollution control agency.

The then Regional Manager of the Waterways Commission suggested to Wayne Clarke, a member of ARMA, to look at developing a 'friends' group in the Toodyay area. Advertisements in the local community newspaper resulted in an inaugural meeting of three community members in Toodyay's Duidgee Park on 10 December 1994. The founding members, Wayne and Desrae Clarke and Bob Frayne, continue their active roles to this day.

The specific aim of the initiative was to involve the community in the rehabilitation of the river and its tributaries. The process would include the control of feral plants, the rehabilitation of the foreshores and floodplain by endemic plantings and the removal of rubbish within the riverine environment. With further advertising the group expanded in membership and consolidated its management structure achieving incorporation four years later in 1998.

Since then, the group has gone from strength to strength, consistently achieving successful conservation and community engagement outcomes. A large part of this fruitful journey has been the dedication of its membership. At the helm is a strong management committee which includes a project officer and a media position (Clarke 2008).

**Engagement**

TFOR has long understood the benefits of effective community engagement and does this in a number of ways. The group works hand in glove with Toodyay Shire and local heritage

focussed organisations with cross membership being common. A sub-group of TFOR is the Seed Orchard Group where volunteers lead by former Landcare Officer Bethan Lloyd gather providence seed and propagate thousands of seedlings annually for local revegetation and rehabilitation projects (Fig. 1).

Traditionally, a monthly article in the local newspaper was (and still is) an effective way of informing residents and members of planned activities, meeting times and dates and so forth. Now a website and social media is where many go for information. The group also produce a newsletter called "Biddip" that is available in electronic form and hard copy. Articles and photos are contributed by members. These issues not only disseminate information but also chart the history of the club.

Every year Toodyay stages its popular Agricultural Show and local conservation groups band together to present an "environmental matters" display. During the day hundreds of people pass through providing an exceptional opportunity for TFOR to engage with the public.

Winter tree planting is always on the annual program and community members including school children are invited to participate in these events (Fig. 2). Fund-raising activities provide a valuable contribution to the club's running costs and also raise its public profile.

Apart from close associations with local community groups, the TFOR participates with other agencies and committees. The Avon Descent organisers call on TFOR to assist with logistics, river access points and parking etc. The Department of Fire

**Figure 1.** Community tree planting event at Harper Brook, a tributary of the Avon River. Photo: G. Warburton.

**Figure 2.** Tree planting along the section of the Avon River along Toodyay township. Photo: G. Warburton.

and Emergency Services consult with TFOR during their seasonal bush fire mitigation work along the river. The formation of a local Aboriginal Corporation, Noongar Kaartdijin Aboriginal Corporation (NKAC) and the adoption of a Shire Reconciliation Program has seen TFOR become a key player in the interpretation and care of significant Aboriginal sites along the river.

However, it was the group's association with the Department of Water's Northam Office over many years that provided great impetus and legacy. Projects and activities implemented by the Department included "rivercare" workshops, revegetation, erosion control and river pool dredging. This Department is no longer based in the region but the River Recovery Plans they published and the expertise, support and dedication of the staff from that time have left a lasting legacy. The Department also hosted the Avon Waterways Committee. It has now been replaced by a community initiative under the name CARE (Conserving the Avon River Environment) which currently provides representation and a forum for groups and stakeholders throughout the catchment.

## Projects

Over the years TFOR has embarked upon numerous specific projects. Some have been funded externally, with many sustained by the Department of Water (Government of Western

Australia 2022). Local sponsors have contributed, and the Shire Council recognises the value of supporting the group's activities.

In 2003 TFOR successfully negotiated a management agreement on 6 ha of riverside land transferred from the Lloyd Family to the State of WA. Named Lloyd Reserve, it now serves as a useful location to showcase TFOR's river care and amenity improvements.

TFOR has taken advantage of Greencorp, Green Army and prisoner work crews to assist with the bigger tasks. A good example has been the ongoing and gargantuan task of removing tamarisk (*Tamarix parviflora*) infestations. TFOR has installed monitoring points and these are used as strategic reference locations for members to record and report riparian and river conditions. Winter tree and sedge planting is locked into the yearly program and encompasses not only new sites but infill plantings, ground preparation and weed control (Oversby 2004; Hussey *et al.* 2007).

Specific seasonal water bird surveys are often conducted with Birdlife Australia. Sectional surveys and inspections have been carried out by members who "adopt" a part of the river. Recording problems or threats to the river like the presence of invasive weeds such as bridal creeper (*Asparagus asparagoides*) and castor oil plant (*Ricinus communis*) provides invaluable data (Australian Government 2010). Storm water runoff from the town catchment into the river has long been a concern for TFOR. In 2020 the group secured funding to construct an impressive system of rock pitching, weirs and culverts below the outlet of the main town drain. Now, the previous ongoing erosion issues have been eliminated and a constructed wetland reduces the discharge of nutrients and pollutants into the river.

**Work**

Central to the TFOR ethos are the regular monthly working bees (Figs 3–6). These are scheduled for Sunday and Monday mornings and allow for more members to participate. The group is well-equipped with a work trailer and a large range of tools. Equipment includes water quality testing apparatus, chainsaws, whipper snippers, augers, chemical spraying units and tree planters. All this is stored in a purpose-built shed which is shared with the Seed Orchard Group. At the end of the physical task members often socialise and there is always a sense of achievement and enjoyment. General and Management Committee meetings are held on a regular basis.

**Figure 3.** Toodyay Friends of the River working bee: repairing erosion from a storm water outlet. Photo: G. Warburton.

**Figure 4.** Working bee success: water flow from the storm water outlet, winter 2021. Photo: G. Warburton.

**Figure 5.** Toodyay Friends of the River working bee: removing castor oil plants. Photo: G. Warburton.

## Tracks

TFOR has long known the importance of connecting people to the river to raise awareness of its environmental and heritage value. One of the most effective ways to do this is through walk tracks. With funding from Lottery West and the Department Local Government, Sport and Cultural Industries, TFOR volunteers created the Bilya Walk Track. Starting at Duidgee Park it follows the river bank upstream 6 km to the pioneer cemetery at Nardie. Walkers can safely experience the riparian environment and various special sites along the way.

The track features interpretive signage, seating, rest stations, foot

**Figure 6.** A footbridge on the Bilya Walk Track. Photo: G. Warburton.

bridges, a picnic shelter, canoe ramp, a bird hide and memorials. A disabled access point to the track has been recently installed. Since its creation nearly 10 years ago the track has become increasingly popular with residents and visitors alike. A guide brochure was produced by TFOR and made available at the Visitors Centre. Walk tracks are now core business for the TFOR with several other spur tracks and loops being developed. Currently, planning for a "trail hub" is underway where additional information and amenity will be provided for walkers. Recently, TFOR presented these initiatives and achievements at a successful community Walk Track Forum.

## Future

TFOR now approaches 30 years since that very first meeting. Its long track record of achievement was recognized by the Shire at the Australia Day awards in 2022 with the presentation of the Community Group of the Year Award.

With the limited capacity of government agencies to manage our waterways and increasing pressures on our natural environment, the role of TFOR and similar groups are more crucial than ever. Although challenges lay ahead, with increasing membership and recognition, TFOR is in a strong position and looks ahead with confidence.

## Reflection

An iconic location on the Avon River is a place known as "Cobbler Pool" named for the species of fish that were once caught there. Sadly, the Cobbler

(*Tandanus bostocki*) are now gone. This reminds us of the memories of former TFOR President, Gaven Donegan, who remarked:

> I was born on the Avon River at Cobbler Pool in 1941. I enjoyed learning about the river, its moods and the creatures it supported. The river pools were wide, deep and beautiful. My Dad said to me "always respect the River." (p. 2; Clarke 2008)

Gaven's words truly capture the spirit of the Toodyay Friends of the River, whose love of the river compel them to look after it for current and future generations.

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# The Western Desert Taipan, *Oxyuranus temporalis* (Elapidae): Additional observations and a revision of its distribution, occurrence and occupancy in Western Australia and the Northern Territory

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**Abstract**

The Western Desert Taipan (*Oxyuranus temporalis*) is one of the most poorly documented Australian reptiles. Only a small number of individuals have been found from a few widely spaced localities in central-southeastern Western Australia and the southwest of the Northern Territory. Here, we detail recent observations that extend the geographic range of the species further westwards, significantly increasing its known distribution.

## Introduction

The Western Desert Taipan (*Oxyuranus temporalis*) is a large species of terrestrial elapid snake known only from the sandy deserts and rocky ranges in central-eastern and lower-eastern Western Australia (WA) and the southwest of the Northern Territory (NT). The species was originally described from a single specimen collected in 2006 from the Walter James Range in central-eastern WA (Doughty *et al.* 2007). Although no other specimens were recognized at the time of the description, a probable historic specimen was highlighted by Shea (2007), with a specimen fitting the description collected from the George Gill Range in the adjacent NT in 1894, approximately 290 km east of the Walter James Range. This specimen, however, was unable to be located (Shea 2007) and with only one confirmed specimen at the time of description, nothing further could be inferred about its distribution.

Since 2007, several more specimens have been encountered. Most notably in 2010, with the discovery and collection of four specimens from the Ilkurlka region of WA in the Great Victoria Desert (GVD) which resulted in a redescription of the species (Brennan *et al.* 2012). This series of specimens provided valuable information on the overall ecology and biology of the species, including some further genetic work, and also extended the known distribution southwest by over 400 km. More recently, the collection of a road-killed animal in the NT provided confirmation of the species occurring in the NT (Black *et al.* 2020), extending the range eastwards by almost 300

km. Other reliable observations have also been made from the broader Ilkurlka region over the last 5–10 years and several encounters have also occurred along the Great Central Road between Warburton and the WA–NT border to the south-west of the Walter James Range (Atlas of Living Australia 2021), including an observation near Mantamaru (R. Browne-Cooper, pers. comm.). Additional recent observations have also been made in the vicinity of Watarrka in the NT, in close proximity to the 1894 record (C. Jolly, pers. comm.).

The first formal IUCN assessment of the species was undertaken in 2017 (Shea *et al.* 2017). With few records available to assess its geographic range, occupancy calculations produced an Area of Occupancy (AOO) of only 8 km$^2$ and an Extent of Occurrence (EOO) of only 3 km$^2$ (Chapple *et al.* 2019). The EOO figure presented in Chapple *et al.* (2019), however, is erroneous, with the true figure at the time recalculated using the same records of 12,490 km$^2$ (S. Macdonald, pers. comm.). These figures almost certainly understate the actual geographic range of the species.

Here we report on two independent observations of *O. temporalis* observed in the far west of the GVD region of WA, approximately 230 km northeast of Laverton and 270 km southwest of Warburton, greatly extending the species' known distribution. We provide information here to significantly increase the species' known EOO. We also use records from 15 independent locations incorporating 18 observations to provide a revised estimate of AOO. In addition, we also further highlight some behavioural and physiological characteristics initially reported by Brennan *et al.* (2012), including temperament and seasonal colour variation.

## Observations

Two separate observations were made of *O. temporalis* between January and October 2021 in the vicinity of Tjukayirla Roadhouse, WA, approximately 250 km southwest of Warburton and 300 km west-northwest of Ilkurlka (the closest known localities). The observations were made approximately 35 km apart along the Great Central Road southwest of Tjukayirla Roadhouse near the north-eastern edge of Lake Throssell.

### Observation 1

An observation of *O. temporalis* was made by AL on 12 January 2021 at 1036 h on the Great Central Road approximately 40 km southwest of Tjukayirla Roadhouse, WA, at -27.425083°, 124.313389° (Fig. 1). A large (approximately 1600 mm total length), darkly coloured individual was observed from a vehicle on the edge of the Great Central Road. Although recorded mid-morning, conditions were mild and there was some cloud cover. The snake was initially observed motionless in the spoon drain on the side of the road; upon stopping the vehicle, it started to move slowly across the road. The snake was approached on foot and subsequently observed and photographed for several minutes as it slowly crossed the road, at one point coming within 2 m of the observer. During this time, the snake showed no signs of agitation as it made its way slowly across the road, seemingly unperturbed by the close proximity of the observer.

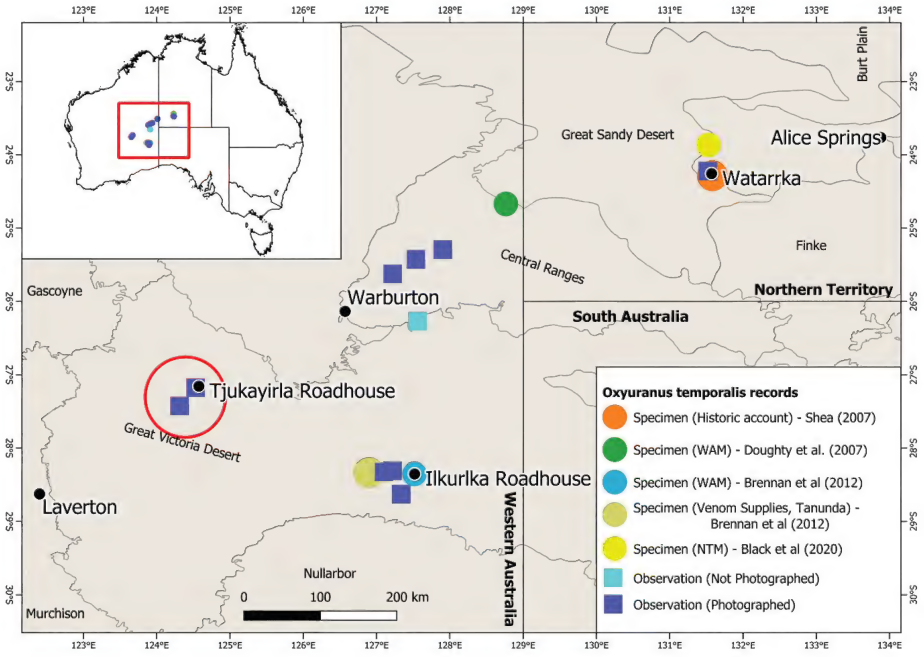


**Figure 1.** Map of central eastern Western Australia, southwestern Northern Territory and northwestern South Australia highlighting the main IBRA bioregions within these areas (upper left-hand map shows the general location within Australia). Occurrences of *Oxyuranus temporalis* are based on specimen records from the WAM (green dots) and Northern Territory Museum (yellow dots) and/or captive specimens taken from known locations (olive dots), the 1894 historic record (orange dots), as well as confirmed (photographic) sighting records from Atlas of Living Australia and several personal communications (blue squares) and the unphotographed record from Mantamaru (light blue square). The two blue squares within the red ring represent the current, photographed observations.

Photographs (Fig. 2) were later sent to RL and identified as *O. temporalis*, which was confirmed after sending the photos to Paul Doughty (WA Museum), Mark Hutchinson (South Australian Museum) and Brad Maryan. The characters that could be seen in the photographs conformed to *O. temporalis* such as the paler snout and dark upper lateral margins of the ventral scales, features not generally seen in similar-sized snakes in the region such as the Western Brown Snake (*Pseudonaja mengdeni*) or Mulga Snake (*Pseudechis australis*) (see Black *et al.* 2020) or the Inland Taipan (*Oxyuranus microlepidotus*), the geographically closest relative to *O. temporalis*, though not known to overlap in distribution or habitat.

The dominant habitat at the site of observation consisted of sandplain vegetated with sparse mulga woodland (*Acacia caesaneura*) over low shrubland (*Eremophila miniata* and *A. ramulosa*) over tussock grassland (*Monachather paradoxus*) (Fig. 3). Low sandy rises with scattered hummock grasses

**Figure 2**. *Oxyuranus temporalis* (Observation 1) observed crossing the Great Central Road 35 km south-west of Tjukayirla Roadhouse, Western Australia. Photo: A. Lennie.

**Figure 3**. Habitat of first specimen observation, consisting of sandplain vegetated with sparse mulga woodland (*Acacia caesaneura*) and low shrubland (*Eremophila miniata* and *A. ramulosa*) over tussock grassland (*Monachather paradoxus*). Photo. R. Lloyd.

(*Triodia* sp.) occurred approximately 100 m south of the road, while the mulga/tussock grassland habitat continued to the north where it is suspected to reach the isolated dunes, gypsum rises and chenopod shrubland habitats surrounding Lake Throssell < 1 km away.

**Observation 2**

A second observation of *O. temporalis* was made by RL and B. Metcalf on

22 October 2021 at 0615 h also on the Great Central Road approximately 5 km southwest of Tjukayirla Roadhouse, Western Australia at -27.174649°, 124.532360° (Fig. 1). A large (approximately 1400 mm total length), pale individual crossing the Great Central Road was seen from a vehicle. Although relatively early in the morning (approximately 1 h after sunrise), conditions were mild with a temperature of 21°C and a light breeze. The species was immediately identified using characters highlighted in Brennan *et al.* (2012), particularly the darker upper lateral margins of the ventral scales, which were clearly discernible from some distance away. Upon approaching the snake, it showed no signs of nervousness or agitation, and no attempt was made by the snake to rear up or make a quick retreat as it continued to move slowly across the road. On approaching within about 2 m of the snake, slight flaring of the neck region was observed, and it often would stop and raise its head slightly, turning its head to follow the observer's movements, regularly flicking its tongue, while continuing to move slowly to the edge of the road. Once off the road, the snake then gradually gathered speed, retreating into thick vegetation at the base of a large mallee. The individual was photographed *in situ* and its habitat noted (Figs 4, 5).

The dominant habitat (Fig. 5) at the site of observation consisted of fire-affected sandplain with widely spaced, isolated sand dunes (as opposed to the regular series of parallel ridges seen in other parts of the GVD). Vegetation consisted of sparse mallee woodland (*Eucalyptus youngiana*) and shrubland (*A. ligulata* and regenerating *Dicrastylis brunnea*) over hummock grassland (*Triodia basedowii*) and tussock grassland (*Aristida holathera*). Small, isolated mulga thickets were also scattered throughout the landscape. The area is also in relatively close proximity to small rocky ranges, particularly those occurring to the north towards Empress Springs, including Breaden Bluff (along the David Carnegie Road) and Nullye Soak (along the Great Central Road). Isolated small breakaways, rock holes and gravelly rises are also present in and around the nearby Tjukayirla Roadhouse.

**Figure 4**. *Oxyuranus temporalis* (Observation 2) observed crossing the Great Central Road 5 km south-west of Tjukayirla Roadhouse, Western Australia. Photo: R. Lloyd.

**Figure 5**. Habitat of second specimen observation, consisting of fire-affected sandplain with widely spaced, isolated sand dunes dominated by grassland (*Triodia basedowii* and *Aristida holathera*) with a sparse overstorey of Mallee (*Eucalyptus youngiana*) and isolated low shrubs (*Acacia ligulata* and *Dicrastylis brunnea*). Photo: R. Lloyd.

## Discussion

### Geographic distribution

The current observations extend the known distribution in WA westwards by approximately 265 km to the Tjukayirla/Lake Throssell area of the western GVD. This takes the known east-west (northeast-southwest) distribution of *O. temporalis* to over 800 km, encompassing four bioregions (Macdonnell Ranges, Great Sandy Desert, Central Ranges and GVD) from the most easterly locations near Watarrka in the NT through to the current western localities near Lake Throssell in WA (Fig. 1). This now represents a much larger distribution than previously reported in recent publications (Chapple *et al.* 2019; Wilson & Swan 2021).

With the new western specimens, as well as other observation-based records not used in the 2017 IUCN assessment, the estimated EOO of *O. temporalis* is now 144,642 km$^2$. This represents a significant increase in the EOO since original assessments, with the EOO now over ten times larger than previously reported for this species. The AOO, however, has only increased to 60 km$^2$, due to the addition of only 13 extra 4 km$^2$ grid cells. The small AOO likely reflects the low encounter rate of the species (probably due to the remote location, rather than it being a truly cryptic species), rather than an actual limit of its distribution and more encounters will increase the AOO. Likewise, with any future records outside of the revised distribution, the EOO will only continue to increase.

The areas where *O. temporalis* had previously been recorded include sandy flats associated with rocky ranges in the Central Ranges bioregion (Doughty *et al.* 2007), creek lines and rocky ranges in the Macdonnell Ranges bioregion (Shea 2007), sand dune desert without any nearby rocky range or breakaway country in the GVD bioregion (Brennan *et al.* 2012), and

**Table 1**. Localities of *Oxyuranus temporalis* specimens and observations. Records with an asterisk (*) are those unable to be examined due to lack of specimen and/or photographic evidence.

| General Location | IBRA Region | Year | Evidence | # | Source |
|---|---|---|---|---|---|
| George Gill Range, NT | Macdonnell Ranges | 1894 | Account | 1* | Shea (2007) |
| Walter James Range, WA | Central Ranges | 2006 | Specimen | 1 | Doughty *et al*. (2007) |
| Ilkurlka Roadhouse, WA | Great Victoria Desert | 2010 | Specimen | 3 | Brennan *et al*. (2012) |
| Ilkurlka area, WA | Great Victoria Desert | 2010 | Specimen | 1 | Brennan *et al*. (2012) |
| Ilkurlka area, WA | Great Victoria Desert | 2014 | Photographic | 1 | B. Maryan, pers. comm. |
| Warburton area, WA | Central Ranges | 2015 | Photographic | 1 | V. Dunis (via ALA, 2021) |
| Ilkurlka area, WA | Great Victoria Desert | 2016 | Photographic | 1 | L. Gilding, pers. comm. |
| Warburton area, WA | Central Ranges | 2016 | Photographic | 1 | C. Hay (via ALA, 2021) |
| Warakurna area, WA | Central Ranges | 2016 | Photographic | 1 | T. Parkin (via ALA, 2021) |
| Ilkurlka area, WA | Great Victoria Desert | 2017 | Photographic | 1 | R. McGibbon, pers. comm. |
| Larapinta Hwy, NT | Great Sandy Desert | 2017 | Specimen | 1 | Black et al. (2020) |
| Mantamaru (Jameson) Area, WA | Great Victoria Desert | 2018 | Observation only | 1* | R. Browne-Cooper, pers. comm. |
| Watarrka area, NT | Macdonnell Ranges | 2020 | Photographic | 2 | C. Jolly, pers. comm. |
| Lake Throssell area, WA | Great Victoria Desert | 2021 | Photographic | 1 | Current (AL) |
| Tjukayirla Roadhouse area, WA | Great Victoria Desert | 2021 | Photographic | 1 | Current (RL) |

sandplain desert in the Great Sandy Desert bioregion (Black *et al.* 2020), with a general impression that the species favours sandy deserts (Black *et al.* 2020). The current observations also conform with this connection to sandy desert, and if the species truly favours sandy desert country, there is a high likelihood that the species will be encountered further afield, particularly where sandplain desert habitats dominate the landscape and there is continuity of habitat.

The potential further distribution outside of this current revised distribution is unknown. Genetic evidence suggests that *O. temporalis* is much more likely to have a large, continuous population (as opposed to several relictual populations) (Brennan *et. al.* 2012), as such, it is assumed that its distribution will continue uninterrupted throughout the current known range, extending throughout much of the GVD, the Central Ranges and possibly into the Gibson Desert. There is also the likelihood that its distribution will extend further into the Macdonnell Ranges to the east and possibly into the Finke. The distribution is also likely to further extend into the Great Sandy Desert to the north and possibly the eastern edges of the Murchison and Gascoyne Regions to the west, particularly where sandy desert country persists. The potential extent of their distribution in the GVD to the south and southwest of the Tjukayirla area also remains largely unknown. Sandy desert habitats persist well south and west of Tjukayirla Roadhouse, with sandplain and sand dune desert extending several hundred kilometres south through Yeo Lake, Lake Rason and beyond. Given the close proximity to salt lakes seen in the current observations, there is a high likelihood its occurrence will extend much further south in GVD, particularly throughout the extensive dune field habitats extending throughout these areas, which are dominated by marble gums, mallee and spinifex, and also mulga woodlands (R. Lloyd, pers. obs.), which are very similar to those habitats outlined for the Ilkurlka observations (see Brennan *et al.* 2012). However, further observations and surveys, particularly at times when small mammal numbers may be high may result in a higher encounter rate of the species. As a mammal specialist, the decline in many Australian mammal species may have negatively affected its numbers. Surveys of mammal abundance and diversity might be informative in predicting or explaining the occurrence of this species, particularly during mammal population explosions or 'boom' periods, when encounters and/or numbers of snakes can also increase, for example *O. microlepidotus* and rodents (Long-haired Rat [*Rattus villosissimus*] and Plains Rat [*Pseudomys australis*]). Ecological/climate modelling may also help to determine and/or predict a potential greater distribution of the species.

**Behavioural and physiological notes**

Additional noteworthy information on the current observations concerns the behaviour exhibited by the snakes. It was apparent to both observers that the snakes were very calm and did not show any major signs of agitation as is often seen with other large snake species, particularly Brown Snakes (*Pseudonaja* spp.). *Pseudonaja* are generally known to have a rather nervous disposition (Gillam 1979), often appearing highly

agitated when startled or approached. This is often displayed through the raising of the forebody into an 'S-shaped' defensive stance. The behaviour can be erratic and is often coupled with the occasional strike, sometimes without any provocation. The observations reported here for *O. temporalis* describe a snake that exhibits some level of confidence, and possibly inquisitiveness, preferring to either remain still, or move slowly and maintain a watchful eye on the observer. This inquisitiveness and calmness has also been reported for specimens observed near Ilkurlka (Bush 2015), including those taken into captivity (Brennan *et al.* 2012), as well as other species such as *O. microlepidotus*, which has been described as a shy, placid snake which will allow one to approach quietly (Emmott & Wilson 2009). Some defensive behaviour was mentioned for the holotype (Doughty *et al.* 2007); however, the snake was narrowly missed by a vehicle when sighted on the road, where it subsequently adopted a defensive S-pose instead of fleeing, though with a nudge from the pinning stick, the snake started to retreat (M. Hutchinson, pers. comm.). This individual is possibly the only sub-adult snake encountered so far and being a smaller individual, may be quicker to adopt a threat display (M. Hutchinson, pers. comm.). Two adult specimens were also observed during the same trip when the holotype was collected, which were later confirmed by photographs, both snakes behaved in a relaxed manner (M. Hutchinson, pers. comm.).

The colours of the two animals observed here also conform to characteristics mentioned in Brennan *et al.* (2012) whereby the snakes' colour typically lightens during spring (Sept-Oct) and tends to darken with the onset of autumn, showing a contrast between the paler herring-bone pattern often observed in this species. The species is then known to turn a dark, chocolate brown in winter, losing most signs of the herring-bone pattern. The initial observation was in mid-January (summer) but was clearly much darker in colour than the second observation in October (spring). Although the darker colour of the first individual was observed during summer, slightly earlier than previously reported, this tendency to darken is thought to be a physiological adaptation to the onset of cooler weather to assist in thermoregulation, a condition also seen in some other large elapid species, including *O. microlepidotus* (Mirtschin 1982; Read 1994).

## Conclusions

The metrics of distributional range, EOO and AOO, of *O. temporalis* are going to increase as more specimens are encountered. In WA, most of the areas in which *O. temporalis* is known to occur have received little survey attention in relation to other areas of arid WA (i.e., the Pilbara) (see How & Cowan 2006). This is coupled with most of its known distribution occurring over an area with poor accessibility and a low human population. The estimated distribution of *O. temporalis* will likely expand further over time, potentially encompassing a larger part of the GVD, and is highly likely to occur in neighbouring bioregions such as the Finke, Gibson and further into the Great Sandy Desert, and potentially even the extreme eastern edge of the Murchison, Gascoyne and Little

Sandy Desert. Access throughout these regions is improving and as such, the probability of additional encounters will also increase. Prior to 2006, this species had potentially remained out of sight since 1894 (possibly just blending in with the superficially similar Western Brown Snake) and now, 15 years since its description, a significant number of observations have already been made, further improving our understanding of this rarely-encountered species.

## Acknowledgements

Thanks to Josef Schofield for sending through photos from the initial observation (AL) to RL; and to Paul Doughty, Mark Hutchinson and Brad Maryan for providing further positive identifications of the snake for Observation 1. Thanks to Jen Wilcox (Western Wildlife) for providing survey opportunities in the Tjukayirla area and Brendan Metcalf for assistance during Observation 2, also to Paul Doughty for initial discussions and comments on earlier drafts of the manuscript. Thanks to Brad Maryan, Rob Browne-Cooper, Lachlan Gilding and Ross McGibbon for providing locality information from their own observations in the field, Chris Jolly and Brendan Schembri for highlighting some recent photographic observations from the NT, and Jim and Aidan Williams (Botanica Consulting) for providing vegetation descriptions of the observation sites. Thanks also to Ryan Ellis (Biologic Environmental) for producing the map figure, Stewart Macdonald for calculations of EOO and AOO figures and comments on an earlier draft and Mark Hutchinson and Damien Esquerre for reviewing the manuscript.

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# Obituary

## George William Kendrick
## June 1929 – November 2014

George William Kendrick was born in June 1929 in Perth, Western Australia (WA). His family lived on Charles Street in North Perth at a time when Smith's Lake was surrounded by market gardens and the city gave way to grazing land and bush only a few miles further north. He attended North Perth Primary School, Perth Boys' School in central Perth, and later Perth Modern School in Subiaco. George's parents separated when he was young and he was raised by his mother, who worked as a housekeeper in Perth and WA's south west. By his teens George had joined the Boy Scouts, for a while acting as an Air Raid Warden messenger in central Perth during the war years. George and his mother lived at Swan View on the Darling Scarp for some time and there developed his life-time love of bushwalking and nature. George walked all over the Darling Range with his Rover Scout group and alone, an activity that soon expanded throughout WA's south west.

A voracious reader, George also kept notebooks of his travels with natural history observations and species records, a habit that continued throughout his life and produced a remarkable record. George's passion for natural history led him to the like minds of the WA Naturalists Club and the WA Speleological Group. He remained a life member of both organisations and was also a member of other organisations such as the Malacological Society of Australasia. Over time he developed a deep knowledge of Western Australian botany, geology and zoology in general, and particularly for both non-marine and marine molluscs. Not only a naturalist, George also cared strongly for the preservation of nature and was a dedicated conservationist throughout his life (Fig. 1).

With university financially beyond his reach, George entered the workforce at the Royal Perth Hospital pathology laboratory in 1947. He later became a 'wharfie' at Fremantle Harbour including a period working on the pilot boat Lady Forrest. In the

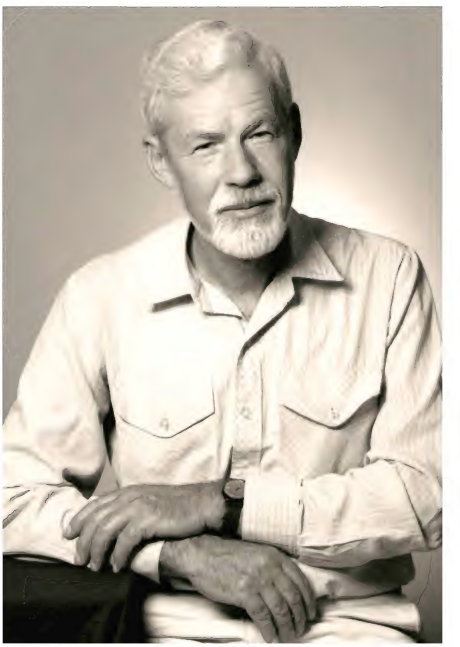

**Figure 1**. George William Kendrick in 1990. Photographer unknown.

1950s, he became active in community affairs, including social justice and welfare issues, and unsuccessfully ran twice for the Parliament of WA.

George married Wendy Gilchrist in 1955 and they settled in the then-new suburb of Willagee. Sons Peter and Alan were born in 1961 and 1963, respectively, and both eventually followed George into careers in the natural sciences. Kendrick family camping holidays ranged all over WA, invariably visiting fossil localities and locations where the iconic Western Australian land snail genus *Bothriembryon* occurred along the way. WA's south coast was a favourite destination, and many holidays were spent at places like the Stirling Range, Windy Harbour, Two Peoples Bay, Frenchman Bay and the Walpole and Nornalup inlets. George's focus on natural history never diminished.

With guidance from senior colleagues like Bert Main and Ernest Hodgkin, he made his first steps into publishing and assisting with WA Museum (WAM) fieldwork. His first publication was based on natural history observations made while working as a wharf labourer in the late 1950s, and typically showed a concern for the spread of non-native species. In 1961, George journeyed to the islands of the Dampier Archipelago and through the Pilbara on a museum collecting trip with colleague Barry Wilson and volunteer Doug Bathgate.

In early 1965, George joined the WAM as Technical Assistant in the Department of Palaeontology. His supervisor was Duncan Merrilees, who became a mentor and life-long friend, and George soon embarked on official WAM field collecting expeditions. His early museum years included collecting trips to the Hamersley Range and caves of the Cape Range. In 1966, he retrieved the museum's famous mummified example of the now-extinct marsupial Tasmanian tiger (*Thylacinus cynocephalus*) from cave N63 (now Thylacine Hole) on Mundrabilla Station, 100 km west of Eucla, and accompanied it back to Perth by rail. In 1966 and 1967, George, with Athol Douglas and Ken Buller, made the first of what would be many WAM trips to investigate the Gogo formations in WA's Kimberley region, now famous as a source of remarkably preserved Devonian fish fossils. A major expedition from the British Museum joined them in 1967 (Fig. 2).

Closer to home, George commenced a long-term study of the marine fossil beds of the Swan River and coastal plain, initially based on his observations of the fossil beds visible along the river at places like Peppermint Grove and Minim Cove. After meeting the water boring contractor Jack Hastings, George was able to collect many depth-logged samples from water bores sunk on the Swan Coastal Plain. He developed a detailed knowledge of these marine fossil faunas and understood that they indicated major changes in marine environments over time, indicating relatively warmer and cooler climate cycles.

George's early works were mainly on local malacology and in 1976 he published an account of the degradation of the Avon River catchment through land clearing, pollution and engineering, using the freshwater mollusc fauna to illustrate the scale of the destruction wrought on the river by 150 years of agricultural settlement. Collaborating with WAM

**Figure 2.** George Kendrick and colleagues at the Gogo formation in 1967. L to R: Ken Buller (WAM), George Kendrick (WAM), Howard C. Brunton (Natural History Museum, London), Harry Ashley Toombs (Natural History Museum, London). Photo: Ian Rolfe.

archaeologists Kate Morse and Charlie Dortch, George also co-authored papers on mollusc remains within caves, middens and other deposits.

Other significant collaborators included Tom Darragh (Museums Victoria), with whom he conducted seven field trips between 1969 and 2005 investigating the Eocene and Maastrichtian mollusc faunas of WA, R. M. Badve and Ajit Vartak (*Agharkar Research Institute*, Pune, Cretaceous molluscs of southern India), Alan Solem (Field Museum of Natural History, on land snails), and many WAM colleagues including Ken McNamara, Kris Brimmell, Val Ryland, Shirley Slack-Smith, Loisette Marsh, Barry Wilson, Anne Brearley, Jenny Porter and Duncan Merrilees.

In the 1980s, George began a long collaboration with Karl-Heinz Wyrwoll (University of WA), which developed into a detailed understanding of the changing climates and environments of the western coast of WA during the Pleistocene-Pliocene. This collaboration built on George's deep understanding of the Quaternary geology of WA and his ability to extend this to a wider appreciation of related environmental and climate events. His knowledge and the huge field effort involved in attaining this understanding are highlighted by his 1991 paper in the Quaternary Science Reviews. The paper presents the coastal succession of the western margins of Australia, and to this day remains the definitive outline of Pliocene-Quaternary marine events for this region. The paper also provided the impetus for further stratigraphic work by George and colleagues over the following decades.

George first visited India in 1986. Over seven extended visits he travelled extensively, alone and with friends, and collaborated with Indian colleagues in describing middle Cretaceous mollusc faunas. He loved the Subcontinent and its people, and the time he spent there, including extended stays at the Agharkar Research Institute in Pune, sustained him to the end of his life (Fig. 3).

George loved the bush of Western Australia and was a regular visitor to the rugged landscapes of the Pilbara. For many years he led an annual three-day bush walk across the Darling Range with groups of friends and colleagues, and these continued

**Figure 3.** George Kendrik and colleagues at Malvan, north of Goa, India at about 1990. L to R Ajit Vartak with son Rohit, unknown, Pat Vinnicombe, George Kendrick, Shirley Slack-Smith.

until his health declined. His lifelong fascination with and knowledge of the plants of the southwest made these springtime walks a joy for the botanically inclined.

George and Wendy separated in the 1980s. His later partner was rock art anthropologist Patricia Vinnicombe. They lived in Guildford and travelled extensively in Europe, South Africa and India until her death in 2003. George retired from the WAM in 1989 as Assistant Curator but retained an office there and kept up his research and publishing. He was made Emeritus Curator in 2002. His final publication in 2010 was written with his long-term friend and collaborator Tom Darragh. George died peacefully in his sleep in South Perth in November 2014. His lifelong love of food, friends and gardens stayed with him until the end, and his happiest times in later years were enjoying an outdoor meal with friends and family amongst his favourite plants.

**Tom Darragh [1], Winston Ponder [2], Alan Kendrick [3] and Alan Kabat [4]**

[1] Museums Victoria, GPO Box 666, Melbourne, VIC, 3001

[2] Australian Museum, 1 William Street, Sydney, NSW, 2010

[3] Western Australian Marine Science Institution, Indian Ocean Marine Research Centre, The University of Western Australia, Crawley, WA, 6009

[4] Research Associate, Museum of Comparative Zoology, Harvard University, Cambridge, Massachusetts, USA.

## Appendix 1

George Kendrick Publication list

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## Appendix 2

### Taxa named by George Kendrick

*Zenatiopsis ultima* Darragh & Kendrick, 1971

*Coxiella roeae* Kendrick, 1978

*Bothriembryon gardneri* Kendrick, 1978

*Bothriembryon consors* Kendrick, 1978

*Bothriembryon ridei* Kendrick, 1978

*Bothriembryon douglasi* Kendrick, 1978

*Barbatia (Acar) gunsoni* Darragh & Kendrick, 1980

*Austroassiminea* Solem, Girardi, Slack-Smith & Kendrick, 1982

*Austroassiminea letha* Solem, Girardi, Slack-Smith & Kendrick, 1982

*Tellina (Tellinides) cockburnensis* Kendrick & Brearley, 1984

*Giraliapecten* Darragh & Kendrick, 1991

*Grammatodon (Nanonavis) subdiscors* Darragh & Kendrick, 1991

*Pseuolimea flabellata* Darragh & Kendrick, 1991

*Giraliapecten oboloides* Darragh & Kendrick, 1991

*Chlamys (Microchlamys) propesalebrosa* Darragh & Kendrick, 1991

*Chlamys (Chlamys) cracenticostata* Darragh & Kendrick, 1991

*Spondylus schekkermanae* Darragh & Kendrick, 1991

*Panopea stenopleura* Darragh & Kendrick, 1991

*Ampullina butleri* McNamarra & Kendrick, 1994

*Echinolampas tumulus* McNamara & Kendrick, 1994

*Clypeaster butleri* McNamara & Kendrick, 1994

*Conotomaria minacis* Darragh & Kendrick, 1994

*Conotomaria (?) cypsela* Darragh & Kendrick, 1994

*Leptomaria perancisa* Darragh & Kendrick, 1994

*Nododelphinula draconis* Darragh & Kendrick, 1994

*Euthriofusus (?) vandegraaffi* Darragh & Kendrick, 1994

*Austrocypraea amae* Fehse & Kendrick, 2000

*Plicatula (Plicatula) emaciata* Darragh & Kendrick, 2000

*Trochaclis? stillata* Darragh & Kendrick, 2000

*Danilia vialis* Darragh & Kendrick, 2000

*Danilia euglypta* Darragh & Kendrick, 2000

*Pseudoninella? squarrosa* Darragh & Kendrick, 2000

*Micrelenchus (Plumbelenchus) armulatus* Darragh & Kendrick, 2000

*Micrelenchus (Plumbelenchus) lirulatus* Darragh & Kendrick, 2000

*Calliostoma (Fautor) numapum* Darragh & Kendrick, 2000

*Leucorhynchia rotulina* Darragh & Kendrick, 2000

*Leucorhynchia ventricosa* Darragh & Kendrick, 2000

*Collonia variabilis* Darragh & Kendrick, 2000

*Homalopoma (Homalopoma) limnaios* Darragh & Kendrick, 2000

*Tricolia psila* Darragh & Kendrick, 2000

*Bothriembryon kremnobates* Kendrick, 2005

*Venericardia capricornia* Darragh & Kendrick, 2008

*Zeacolpus bartoni* Darragh & Kendrick, 2008

*Cerithium wilya* Darragh & Kendrick, 2008

*Lyria lamellatoplicata* Darragh & Kendrick, 2008

*Periglypta weegeeree* Darragh & Kendrick, 2010

*Dosinia (Kereia) numerosissima* Darragh & Kendrick, 2010

*Conoteuthis azizi* Fuchs, Vartak, Kendrick & Ghare, 2010

## Taxa named for George Kendrick

### Species

*Austrohoplochaetella kendricki* Jamieson, 1971

*Austroharpa kendricki* Ludbrook, 1978

*Timoclea* (*Veremolpa*) *kendricki* Ludbrook, 1978

*Bothriembryon kendricki* Hill, Johnson & Merrifield, 1983

*Calantica (Scillaelepas) kendricki* Buckeridge, 1983

*Sphaerium kendricki* Kuiper, 1983

*Botelloides chrysalidus kendricki* Ponder, 1985

*Terebratulina kendricki* Craig, 1999

*Notochlamys kendricki* Beu & Darragh, 2001

*Gabbia kendricki* Ponder, 2003

*Trivellona kendricki* Fehse & Grego, 2008

*Clavocerithium kendricki* Darragh, 2017

*Bungulla kendricki* Rix, Raven, Austin, Cooper & Harvey, 2018

### Genera

*Kendrickichthys* Dennis & Miles, 1980

*Kendrickia* Solem, 1985

*Kendrickiana* B. Morton, 2004

**From Field and Study**

# Green Tree Frogs (*Litoria caerulea*) on the hop: observations on established populations in the Pilbara

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Despite amphibian populations declining around the world, some species continue to buck the trend. Green Tree Frogs (*Litoria caerulea*) are one of the most well-known Australian frog species (Fig. 1), often kept as pets or observed in people's gardens, toilets or showers in northern Australia's monsoon tropics region (Tyler 1996). The species naturally occurs in the Kimberley, the Top End of the Northern Territory, Queensland and south to New South Wales (Anstis 2002). In Western Australia (WA), naturally occurring populations extend to just south of Broome along the WA coast (Doughty & Tyler 2009).

In the Pilbara region of WA, the establishment of towns, pastoral stations and human-made drainage areas have provided resources suitable for the persistence of *L. caerulea*. These locations are generally isolated areas and artificially watered within a semi-arid environment.

This paper documents both *L. caerulea* sightings (individual frogs) and observations of breeding via frogs heard calling, reproduction or inference of a population based on observations of large numbers of individuals, including metamorphs.

*Litoria caerulea* are known to occur in towns and cities all over Australia through the transportation of flowers and tropical fruits including bananas and pawpaw or other vegetables (Tree 2005). In some states, frog rescue centres have been established to help maintain and rehome such stranded frogs with an estimated 50,000 frogs moved in one year (Tree 2005). In WA, *L. caerulea* have been recorded in Albany, Esperance, Bunbury, Geraldton and various locations around Perth (Armadale Reptile Centre records, pers. comm.). These, however, are likely individual cases of stowaway frogs that travel via fruit and vegetable cartage. Given their natural distribution in tropical areas of Australia, it is unlikely that the species could survive south of Perth.

In the Pilbara, *L. caerulea* are also likely to have been transported via fruits and vegetables; however, due to the proximity of the Kimberley, it is known that hitch-hiking in caravans, four-wheel drives and construction materials have occurred in the past (Armadale Reptile Centre records, pers. comm.). It is also possible that *L. caerulea* has intentionally been introduced by the public into garden

**Figure 1.** Green Tree Frog, Port Hedland. Photo: Glen Gaikhorst.

ponds or greenhouses and have subsequently moved into the natural environment.

During field surveys conducted by us and other consultants in recent years, individual frogs have been recorded in Newman, Pardoo Roadhouse, Pardoo Homestead, Mundabullangana Homestead, Anna Plains Homestead, Anna Plains Bores, Tarcoola Tracking Station, Marble Bar, Eighty Mile Beach Caravan Park, Nanutarra Roadhouse and Exmouth. Most specimens have been observed sitting under dripping taps at accommodation facilities, in toilets, pools, active at night during wet weather or sitting in protected areas near water points, e.g., water feature ponds or water troughs. These locations are presented in Figure 2. Most recently, numerous frogs have been recorded from the Karijini Eco Retreat within Karijini National Park in June 2021 (K. Hopkinson, pers. comm.).

*Litoria caerulea* require a water body for reproduction (Tyler 1994; Anstis 2002, 2013). Doughty and Tyler (2009) report natural spawning sights such as water bodies associated with rivers, drainage lines, soaks, ponds and springs.

Breeding in established populations has been recorded at Onslow, Karratha, Port Hedland, Wedgefield and Sandfire Roadhouse. All of these areas were known to have established populations (or at least breeding populations) at the time of field surveys undertaken between 2008 and 2019. Tadpoles have been observed in roadside ditches, garden ponds, pools, drainage lines and station watering points.

Large numbers of metamorphs have been recorded in and around Wedgefield, Port Hedland and Onslow after rain events. At Wedgefield, metamorphs were identified using Anstis (2013) from photographs and

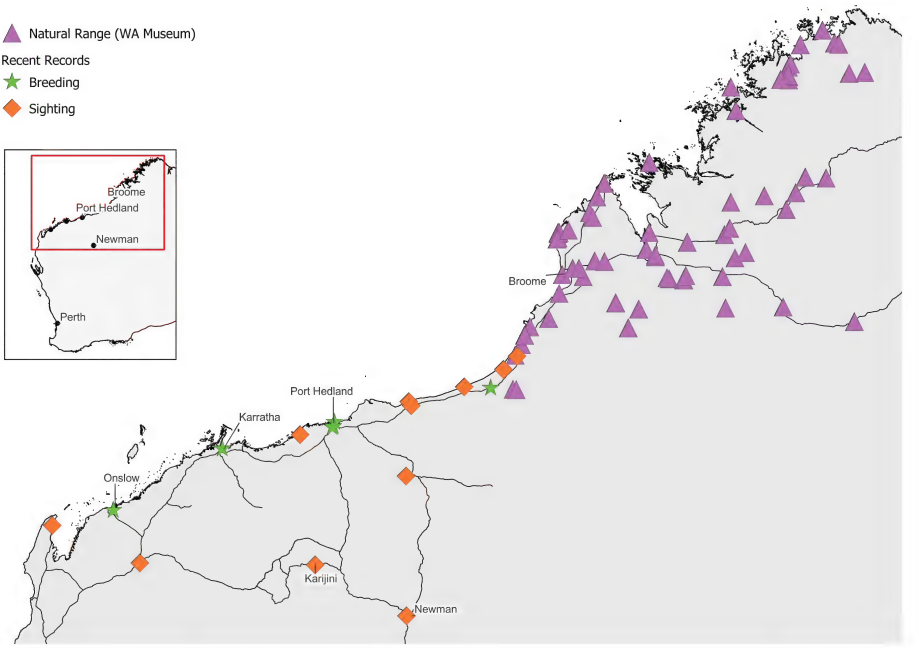


**Figure 2.** Natural range (purple triangles) and range extension sightings (orange diamonds). Breeding events identified as green stars.

while in the hand. Metamorphs were captured also in native vegetation ~1 km away (south from Wedgefield) from human disturbance. However, whether the species can persist away from human-occupied areas is unknown. These locations are also presented in Figure 2.

There are no naturally occurring large arboreal frogs present in the Pilbara. Most species in the region are terrestrial in nature and burrow to escape prolonged dry periods. A small climbing pelodryadid species present is the Desert Tree Frog (*Litoria rubella*); it is also commonly observed in the same human-made habitats as *L. caerulea* although *L. rubella* is widespread in natural environments away from human-made structures.

Although *L. caerulea* in the Pilbara could be seen filling a vacant niche, they are ravenous feeders and locally may feed on or outcompete native species such as small reptiles, mice and birds that come into populous areas; however, no data is available on the impacts of these established *L. caerulea* populations.

*Litoria caerulea* is not the only species (reptile or amphibian) to have expanded its distribution into the Pilbara. Around the Exmouth area large numbers of *Gehyra gemina* (formally *G. australis*) have been recorded utilising human dwellings (pers. obs.) as well as the Northern Laughing Tree Frog (*Litoria rothii*) which can be found around the town of Port Hedland (pers. obs.). Both

species appear to have found their own environmental niche and extended their range south into the Pilbara. The Asian House Gecko (*Hemidactylus frenatus*) is introduced from south-east Asia and is widespread through the Asiatic tropics (Cogger 1995; Hoskins 2011). This species has gradually become established around northern and eastern tropics (Wilson and Knowles 2000, Maryan 2001; Wilson and Swan 2003; Mackay *et al.* 2009; Hoskins 2011; Vanderduys & Kutt 2013), Pilbara regions (Wilson & Swan 2008; Hoskins 2011) and Exmouth of Western Australia (Wilson & Swan 2013). Since then, the species is also known from Carnarvon (pers. obs.) and Monkey Mia (Robert Browne Cooper, pers. obs.), although becoming widespread and abundant around human infrastructure, this species appears to have little impact to native species populations (Vanderduys & Kutt 2013).

This paper provides a snapshot of where *L. caerulea* have extended their range into the Pilbara. Breeding has been recorded in four coastal towns south to Onslow and sightings to Exmouth and as far inland as Newman. It will be interesting over time to see if these species expand south into the cooler temperate regions of WA. With Carnarvon the next major coastal town situated in the mid-west of WA it may only be a matter of time so long as they are physiologically capable of persisting.

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**From Field and Study**

# Notes on the Grey Honeyeater in Western Australia

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The Grey Honeyeater *Lacustroica whitei* occurs in the arid interior of Western Australia (WA) (Johnstone & Storr 2004; Nevill 2021; Serventy & Whittell 1976; Storr 1991) (Fig. 1). It was first discovered by Whitlock at Lake Austin in 1903 and the species was described as the Alfred Honeyeater from a specimen from Wiluna in 1909 (North 1910; Serventy & Whittell 1976). It is inconspicuous, and generally scarce, favouring thickets of mulga and other acacias. Most records are around country towns and mining sites, probably because of monitoring and environmental surveys (Johnstone *et al.* 2013). Its habits are poorly known (Start & Fuller 1993; Higgins *et al.* 2001).

Birds living in the arid zone often respond to rain events (Burbidge & Fuller 2007; Connell *et al.* 2022). Tropical cyclone Charlotte on 27 March 2022 triggered heavy rainfall in the Gascoyne and Central West of WA. As a Grey Honeyeater's nest in red mulga (*Acacia cyperophylla*) had been discovered at Ninghan Station by LB in August 1980, we made several field trips to this site to study their breeding behaviour. The Ninghan site was visited on 12, 20, 21 April; 13–16 May; 24–25 June and 1 July 2022. Additional observations of Grey Honeyeater were made along the road between Yalgoo and Mt. Magnet on 7 October 2021 and 26 June 2022. Both sites are near the southern most part of the range of the Grey Honeyeater in WA (Fig. 1).

The vegetation at the Ninghan site is red mulga, kurara (*A. tetragonophylla*) with eremophila understorey (*Eremophila clarkei, E. compacta, E. eriocalyx, E. forrestii, E. latrobei* (Brown & Buirchell 2011). Both red mulgas and eremophilas were flowering profusely in April, but most had finished by mid-May. There were flowering mistletoes (*Amyema fitzgeraldii, A. nestor, A. preissii*) on the red mulga, but they did not carry berries. At Yalgoo, in October 2021, mistletoes (*A. fitzgeraldii, A. preissii*) were laden with berries.

At Ninghan a nest was found on 21 April (four weeks after heavy rain) in a red mulga, at the end of a horizontal branch. It was oriented in a north-west direction and was about 1.5 m above the ground, which is similar to other reports (Table 1). Geoffrey Lodge (pers. comm.) mentioned he had found two Grey Honeyeater nests 200 m apart at Wagga Station, Yalgoo, in September 1987 (Table 1). In his opinion, Grey Honeyeater nests built in kurara were lower (0.9 m) than those in red mulga (2 m) because of the

**Table 1**. Grey Honeyeater breeding records in Western Australia.Locations with the same letter in parenthesis are the same. Observations by G. Lodge are from the WA Museum nest database.

| Location | Date | Nest location | Nest height | Tree | Nest content | Reference |
|---|---|---|---|---|---|---|
| Wiluna (a) | 23.7.1909 | Extremity of branch | 2 m | Mulga [1] | Nest being built | Whitlock 1910 |
| Wiluna (a) | 15.8.1909 | | | | Nest with 2 eggs | Whitlock 1910 |
| Juna Downs | 21.8.1970 | | | Mulga | Nest with 2 eggs | T. Bush |
| Yalgoo (site 1) | 27.10.1975 | Extremity of branch | 2.5 m | Mulga | 1 advanced nestling | Wells & Wells 1977 |
| Yalgoo | 20.11.1975 | Extremity of branch | 1 m | Kurara [2] | Nest with 2 eggs | Wells & Wells 1977 |
| Yalgoo (same locality as site 1) | 10.10.1976 | | | Mulga | Feeding juvenile | Wells & Wells 1977 |
| Edmund Station, Jula Bore (b) | 28.8.1978 | Outermost twig | >1 m | Mulga | Nest with 1 egg | Curry & Menkhorst 1979 |
| Edmund Station, Jula Bore (b) | 5.9.1978 | Outermost twig | >1 m | | Nest with 1 egg | Curry & Menkhorst 1979 |
| Edmund Station, 20 km SW | 1.9.1978 | | | Acacia | Feeding juvenile | Curry & Menkhorst 1979 |
| Ninghan Station | -.8.1980 | End of forked branch | 1.5 m | Red mulga [3] | Nest with 2 eggs | L. Boyle |

| | | | | | | |
|---|---|---|---|---|---|---|
| Yalgoo, Wagga Station(c) | 4.8.1983 | Extremity of branch | 0.9 m | Kurara | Nest building | G. Lodge |
| Yalgoo, Wagga Station(c) | 14.8.1983 | Extremity of branch | 0.9 m | Kurara | Nest with 2 eggs | G. Lodge |
| Yalgoo (d) | 10.3.1984 | Extremity of branch | 0.9 m | Kurara | Near complete nest | G. Lodge |
| Yalgoo (d) | 23.3.1984 | Extremity of branch | 0.9 m | Kurara | Nest with 1 egg | G. Lodge |
| Yalgoo, Wagga Station(e) | 30.8.1984 | Extremity of branch | 0.9 m | Kurara | Nest with 1 egg | G. Lodge |
| Yalgoo, Wagga Station(e) | 5.9.1984 | Extremity of branch | 0.9 m | Kurara | 1 nestling | G. Lodge |
| Yalgoo, Wagga Station (nest 1) | 6.9.1987 | Extremity of branch | | | Nest with 2 eggs | G. Lodge |
| Yalgoo, Wagga Station (nest 2) | 16.9.1987 | On horizontal twigs | 0.9 m | Kurara | Nest with 2 eggs | G. Lodge |
| Karijini N.P. Mt. Bruce | 22.9.1991 | | | Mulga | Feeding juvenile | Start & Fuller 1995 |
| Karijini N.P. Mt. Bruce (f) | 19.5.1992 | Extremity of branch | 2 m | Mulga | Nest with 1 egg | Start & Fuller 1995 |
| Karijini N.P. Mt. Bruce (f) | 3.6.1992 | Extremity of branch | 2 m | Mulga | 1 juvenile | Start & Fuller 1995 |
| Karijini N.P. Mt. Bruce | 18.8.1992 | Extremity of branch | 2 m | Mulga | incomplete nest | Start & Fuller 1995 |
| Cunyu Station, 80 km N of Wiluna | 17.9.1996 | 30 cm from end of branch | 1.6 m | Red mulga | Nest with 1 egg and 1 nestling | Gole. M 1996 |
| Ninghan Station (g) | 21.4.2022 | End of forked branch | 1.6 m | Red mulga | Nest with 2 eggs | L. Boyle & S. Elson |
| Ninghan Station (g) | 16.5.2022 | End of forked branch | 1.6 m | Red mulga | 2 nestlings | L. Boyle & S. Elson |

[1] *Acacia aneura*; [2] *A. tetragonophylla*; [3] *A. cyperophylla*.

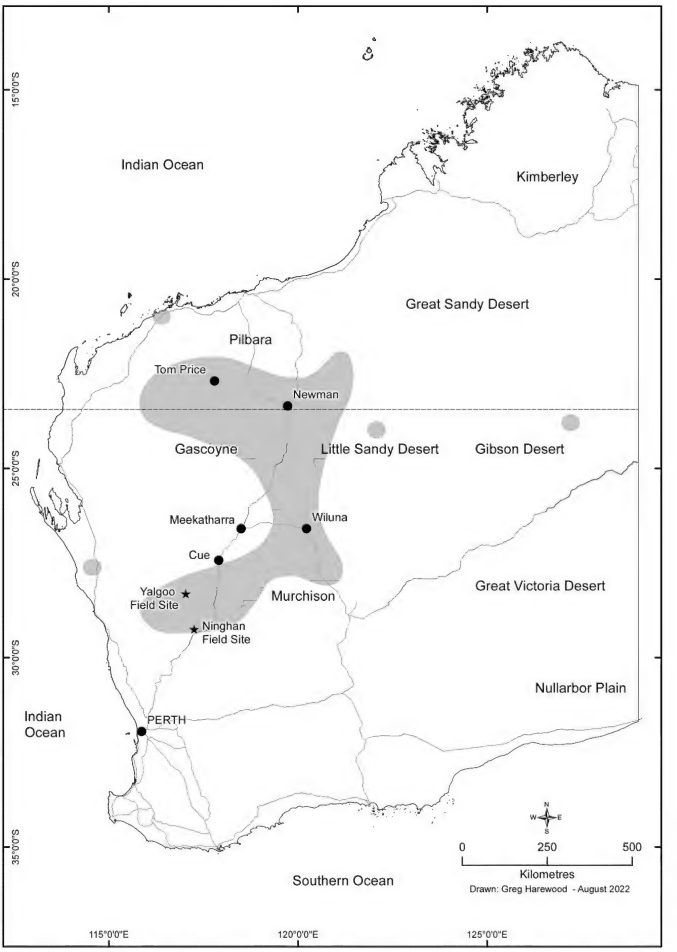


**Figure 1.** Map showing the range of Grey Honeyeater in Western Australia. (after Johnstone & Storr 2004).

tree structure: kurara is a low spreading shrub, whilst red mulga is more upright.

The nest construction was of a light, open weave so the ground could be seen through the nest base and walls, acacia flowers were incorporated along the upper rim of the nest, and it was lined with plant down. White, empty lerp casings were incorporated into the nest (Fig. 2), these are sticky and were used to bind the nest in a similar way to cobwebs (Start & Fuller 1995). Similar white insect cocoons were also observed on the nest found by LB in 1980. There was a small arch over the nest cup which created two entrances. When the Grey Honeyeater accessed the nest from one direction its head would come out of the other, meaning there was only one direction to exit. This differs from previous reports in which the nests are completely open from above.

The nest contained two white eggs with small reddish-brown markings of different size (Fig. 3). The tree which contained the nest was stoutly

**Figure 2.** Construction of Grey Honeyeater nest. Photo: Laurie Boyle.

defended from Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*) and Grey Shrike-thrush (*Colluricincla harmonica*) by the non-incubating bird. Smaller birds visiting the nest tree were chased away, these included Southern Whiteface (*Aphelocephala leucopsis*), Chestnut-rumped Thornbill (*Acanthiza uropygialis*) and Slaty-backed Thornbill (*Acanthiza robustirostris*).

The Ninghan site was re-visited in mid-May 2022 when the nest contained two juveniles (Fig. 4). The young birds were fed by both adults with small green and yellow caterpillars which may have been of the Two-spotted Line-Blue (*Nacaduba biocellata*) that were abundant on some trees (Braby 2019) (Fig. 4). They were also fed pink lerps, a frequently mentioned food

**Figure 3.** Grey Honeyeater nest with two eggs. Photo: Steve Elson.

(Start & Fuller 1995), which were skilfully extracted from their sticky white cocoons. Lerps contain starch and sugars and are energy rich (Sazima & Sazima, 2022).

Other food which we observed included nectar from *E. forrestii* accessed from the outside and base of the flower tube, spiders, and other insects from both red mulga and eremophilas. At Yalgoo in 2021, Grey Honeyeaters were observed plucking mistletoe berries and flying away with single berries in their beak. This behaviour was also observed at Afghan Rock, 40 km NNW of Cue in October 2021.

During the nestling stage most foraging was within 80 m of the nest site, although on several occasions the male foraged more than 100 m away. G. Lodge (pers. comm.) observed Grey Honeyeaters at Yalgoo foraging further away from their nest site, however, habitat near the nest was denuded by livestock and available food sources were likely more distant. At Ninghan they foraged in the company of Slaty-backed Thornbill, Chestnut-rumped Thornbill, Western Gerygoyne (*Gerygone fusca*), Southern Whiteface and Redthroat (*Phyrrholaemus brunneus*). Foraging was in small mixed flocks of five to six birds, with the Grey Honeyeater remaining with them for short spells and then departing.

When the adults returned to the nest tree, they called when they landed to alert the young, they had returned with food. The adults both arrived at the nest tree directly from the trees where they had been foraging for food. At Yalgoo, when the adults returned, they flew high and dropped down when arriving at the nest (G. Lodge pers. comm.). At Ninghan there

**Figure 4.** Grey Honeyeater carrying yellow caterpillars to young. Photo: Laurie Boyle.

were no diversionary tactics, even when the potentially predatory birds Grey Shrike-thrush, Grey Butcherbird (*Cracticus torquatus*) and Spiny-cheeked Honeyeaters were nearby.

During an hour of nest observations, the adults made 15 feeding visits to the nest, mostly with small lerps. The chicks were fed by both adults with the female making nine of the 15 visits. On three occasions both the male and female consumed the faecal sacs. On another two hours of feeding observations, 42 visits were made to the nest with most of the visits made by the female at 2–4 minute intervals. The chick at the rear of the nest received most feeding visits. Both adults pushed the food deep down the throats of the chicks, and then departed quickly to nearby red mulga to collect more food.

On returning to Ninghan on 24–25 June, the nest was vacant, no fledged young were seen, and only one adult bird was present. We spent two hours following a Grey Honeyeater through the bush observing feeding patterns. It stayed within a 500 m radius of the old nest site. It was constantly calling as it moved through the trees and fed among flowering, or in bud red mulga, kurara and another acacia. It did not feed on low-growing, flowering grevilleas.

We observed the plumage of the two adults feeding and attending the nestlings at Ninghan. One adult, taken to be the male, had yellow colouring on the primary and secondary feathers which was noticeable when the wings were folded (Fig. 5); it was not seen on the other, slimmer, bird. This colour variation on the wing feathers might be a post moult feature. Other sources note that flight feathers have a narrow, straw yellow edging, lost with wear; or have a thin yellow-green edge to secondaries or primaries; or have secondaries and tertials narrowly fringed with brownish white or dull yellowish (Menkhorst *et al*. 2021; Johnstone & Storr 2004; Higgins *et al*. 2001). There are few field observations of yellow colouring on the wing.

In contrast to the rest of the grey plumage, the upper tail feathers had a dark brown/blackish band with white tail edges. The birds had a white granulated eye-ring. The bills of both adults had a black upper mandible whilst the lower mandible was pinkish-grey for two thirds of its length with the final third being black. The gape

**Figure 5.** Grey Honeyeater showing yellow wash on primary feathers. Photo: Laurie Boyle. All Photos were taken with Nikon D7100 and D7500 cameras with a 200–500 mm lens.

and rim of the lower mandible was pale yellow.

The plumage of the chicks is described from photographs, close observations and when the chicks stretched their bodies whilst being fed. Their head, crown, back, rump and wings were light brown to almost chestnut. The underbelly feathers were light brown to almost chestnut with a white flush at the base as these feathers were still developing. Much of the belly was still bare of feathers. The inside of the mouth showed a deep, bright orange gape, when the chicks were estimated to be approximately 7–8 days old.

Grey Honeyeater movements are poorly understood; they may be somewhat nomadic. They are generally scarce but may be locally moderately common (Menkhorst 2021; Johnstone & Storr 2004; Higgins *et al.* 2001). The continued sightings of Grey Honeyeater at the same location at Ninghan and Yalgoo, indicate strong, seasonal site fidelity (Table 1), with breeding following heavy rain. It uses a wide variety of food sources such as flying insects, lerps on branches and leaves, caterpillars, nectar and mistletoe berries, allowing it to remain in its territory for a considerable time.

Grey Honeyeater habitat is vulnerable to fires, feral animals and drought (Crates *et al.* 2022). Outback fires can impact Grey Honeyeater's food sources because lerps are fire sensitive, and mistletoes are killed if severely scorched. Mistletoes need their hosts to regenerate sufficiently before they can be recolonised from seed imported from beyond the burnt area (Start 2015). The distribution of Grey Honeyeaters may reflect the severity of past fires (Watson 2021). During dry seasons feral goats graze heavily on the lower spreading branches of prickly kurara, leaving them bare and trimmed, thus reducing nesting sites for Grey Honeyeater (G. Lodge, pers. comm.). Climate change is likely to exacerbate these risks.

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